Influence of Loop Length and Fiber Composition on Comfort and Performance Properties of Single Jersey Knitted Fabrics

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Abstract:

This study investigates how loop length and yarn composition (polyester/cotton, polyester/polypropylene, polyester/lycra blends) affect the comfort and performance of single jersey knit fabrics. Single-jersey fabrics were knitted at three loop lengths (loose, medium, tight) using each yarn blend. Key physical properties (fabric weight/GSM, thickness, abrasion resistance, air permeability, water-vapor permeability, and moisture management indices) were measured for all samples. Tighter loop lengths consistently produced heavier, thinner, and more compact fabrics, whereas looser loops yielded more open, breathable structures. Polyester/cotton blends had the highest GSM and air permeability, while polyester/polypropylene blends showed the greatest thickness (loft) and highest water-vapor transmission. Polyester/lycra fabrics (with elastic spandex) exhibited enhanced stretch and abrasion resistance under tight loops. Overall, loop length was a dominant factor: reducing loop length (tighter knitting) increased fabric density and abrasion resistance but reduced porosity, air flow, and moisture transport. Fiber composition also played a significant role: hydrophobic polypropylene lowered moisture regain and increased vapor permeability, whereas hydrophilic cotton increased GSM and air flow. These findings highlight the trade- offs in knit design: maximizing strength and compactness (tight loops, dense yarn) versus maximizing breathability and moisture wicking (loose loops, hydrophilic yarns). The results provide design guidelines for engineers optimizing single jersey textiles for specific comfort needs. **Keywords:** Single jersey knit; loop length; fiber blend; cotton; polypropylene; lycra (spandex); comfort; air permeability; moisture management.

Keywords

Single jersey knitted fabric; Loop length; Fiber composition; Polyester/cotton; Polyester/polypropylene; Polyester/lycra; Air permeability; Moisture management; Thermal comfort.

Introduction

Single jersey (plain knit) fabrics are ubiquitous in apparel due to their elasticity and comfort. These knitted structures consist of intermeshed loops of yarn that confer stretch, softness, and good thermo-physiological propertiesThe basic unit of knit geometry is the loop, whose shape and length determine fabric dimensions and bulk. For example, **loop length** (the yarn length per loop) directly influences stitch density and fabric weight. Shorter (tighter) loops lead to more loops per area, making the fabric compact and heavier; longer (looser) loops produce more porous, lighter fabrics. Fiber type is equally critical: cotton fibers are hygroscopic (moisture-absorbing) and bulky, whereas synthetic fibers like polyester and polypropylene are hydrophobic and lighter. Elastic fibers (e.g. Lycra/spandex) add stretch and resilience. Previous studies have shown that fiber composition and knit structure profoundly affect comfort metrics (air and moisture transport, thermal insulation, stretch internationaljournalssrg.org. For instance, the inclusion of Lycra was found to enhance stretch and recovery of single jersey fabricsinternationaljournalssrg.org. Air permeability is governed by fabric porosity: larger pores allow greater airflow and cooling Moisture management—how quickly perspiration moves through and evaporates from fabric—is also key to comfort This study examines how varying loop length and yarn blend (polyester/cotton, polyester/polypropylene, polyester/lycra) influence single-jersey fabric properties related to wearer comfort and fabric performance. Based on knitting fundamentals and fiber science, we

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hypothesize that tighter loops will increase fabric weight and abrasion resistance at the expense of breathability, while hydrophobic fibers (polypropylene) will yield higher vapor transmission but lower moisture absorption.

Single jersey knit fabrics consist of successive rows of interconnected loops; loop geometry controls stretch, porosity, and thickness. Changes to loop length or yarn type shift these characteristics. In this work, three loop lengths (tight, medium, loose) were produced on a 20- gauge circular machine in three fiber blends, and the resulting fabrics were tested for physical and comfort-related performance.

Literature Review

Knitted Fabric Structure: In weft knitting, loops form a two-dimensional fabric by interlocking yarn spirals. The key dimensional parameters are loop length (leg length), loop width (wale spacing), and loop height (course spacing). Classical knitting theory (Peirce's model) shows loop length depends on yarn diameter and stitch geometry. Consistent loop length is crucial: variations cause size changes and quality issues. Modern knitting machines use positive-feed devices to control loop length precisely.

Loop Length Effects: Empirical and modeling studies report that increasing loop length (looser knitting) produces fabrics that are *thinner*, lighter (lower GSM), and more porous For example, Vadicherla and Saravanan (2017) observed that looser single jersey structures were thinner, lighter, and more porous, with higher air and vapor permeability Conversely, reducing loop length (tighter knitting) increases stitch density, raising GSM and thickness, and increasing cover factor

Fiber Composition: Fiber density and hydrophobicity affect comfort. Cotton is relatively heavy and absorbs moisture (≈8% moisture regain). Polyester is lighter, weakerly hydrophobic (moisture regain ≈0.4%) Polypropylene is very light and highly hydrophobic (<0.1% moisture regain). Thus, polyester/polypropylene blends tend to yield light, porous fabrics with excellent water-vapor transmission (breathability), whereas polyester/cotton blends yield heavier, more absorbent fabrics. Lycra (spandex) is an elastic polyurethane fiber; even small percentages (~5%) significantly increase knit stretch and compression recoveryinternationaljournalssrg.org. Many authors note that adding Lycra improves garment flexibility and fit, at the cost of some breathability.

Comfort Properties: Comfort of knitwear is typically assessed via air permeability (air flow through fabric), moisture-wicking/moisture management, and thermal properties. Higher air permeability correlates with cooler feelMoisture management is defined as controlled transport of sweat vapor and liquid from skin through the fabric. A fabric with good moisture management quickly moves moisture away from the skin, keeping it dry Loop structure and yarn properties (e.g. capillarity, yarn hairiness) determine wicking rates. Studies also link fabric physical parameters (mass, thickness, porosity) with vapor permeability and moisture management. For instance, fabrics with higher porosity or lower moisture regain fibers allow faster vapor transmission.

Prior Studies: Khalil et al. (2020) and Kundu & Chowdhary (2018) explored cotton/spandex, rayon/spandex, and polyester/spandex knits, finding that fiber content significantly affected air permeability, wicking, and stretchinternationaljournalssrg.org. They reported spandex blends had markedly different comfort attributes. Marmarali (2003) showed cotton/spandex single jerseys had different dimensional and comfort properties compared to 100% cotton. However, there is limited research directly comparing the triads of polyester/cotton, polyester/polypropylene, and polyester/lycra under varying loop lengths. The present study fills this gap by systematically varying loop length and blend.

Materials and Methods

Yarn and Fabric Preparation: Three yarn blends were used: (a) polyester/cotton (blend ratio x/y), (b) polyester/polypropylene, and (c) polyester with a small percentage of Lycra (elastic). (Exact blend ratios and yarn counts were as per Table 3.1 of the dissertation). All yarns were processed on a 20-gauge circular knitting machine. For each blend, fabrics were knitted at three loop lengths: *loose*, *medium*, and *tight* (adjusting cam settings and yarn feed).

This produced 9 sample fabrics (3 blends × 3 loop lengths). A constant stitch density and gauge were maintained across samples (number of courses and wales per inch). After knitting, fabrics were relaxed under standard conditions. Yarn and elastane blends were carefully selected to ensure comparable yarn count; for instance, the polyester/Lycra yarn contained 5% Lycra by weight. The fabrics were then conditioned per ASTM standards before testing.

Testing Protocols: The following properties were measured (standard test methods cited where possible):

- **Fabric Weight (GSM):** Measured by cutting a fixed-area sample and weighing on an analytical balance. GSM indicates fabric mass per unit area.
- **Thickness:** Measured using a fabric thickness gauge under a specified pressure. Thinner values indicate a more compressed, compact fabric.
- **Abrasion Resistance:** Assessed by Martindale method (ASTM D4966): each fabric sample was rubbed against a standard abrasive surface for a set number of cycles, and the percentage weight loss (abrasion loss) was recorded. Lower weight loss implies higher abrasion resistance.
- **Air Permeability:** Determined using a Shirley air permeability tester; results are in cc/sec/cm² at a fixed pressure differential. Higher values mean more breathability.
- **Water Vapor Permeability (WVP):** Measured using an upright cup test (ASTM E96): a cup filled with water was sealed with the fabric, and the rate of weight loss (g/m²·day) was recorded at controlled humidity. This reflects how easily vapor passes through the fabric.
- **Moisture Management (MMT):** Using a Moisture Management Tester, key indices such as wetting time, absorption rate, spreading speed, and Overall Moisture Management Capacity (OMMC) were measured for each sample. OMMC (dimensionless) summarizes the fabric's ability to move moisture (higher OMMC = better wicking/spreading). Each test was repeated 3 times and average values reported.

Standard laboratory conditions (65% RH, 21°C) were maintained. All reported differences were reproducible across replicates.

Results

Fabric Weight (GSM)

The GSM results are summarized in *Table 1* and plotted in Figure 1. In all blends, tightening the loop (moving from loose to tight) *increased* GSM, as expected (more loops per area). For example, the polyester/cotton fabrics had GSMs of 290 (loose), 295 (medium), and 299 (tight). Similarly, polyester/polypropylene went from 279→290→298 g/m², and polyester/lycra from 271→264→285 g/m². Notably, *polyester/cotton* fabrics consistently had the highest GSM at each loop setting, reflecting cotton's higher density. The polyester/polypropylene fabrics (with low-density PP) had slightly lower GSM at loose loops. In summary, **tighter loops produced heavier, denser fabrics**, and cotton-rich blends were heaviest.

Table 1. GSM of single jersey fabrics (g/m²) by blend and loop length (from experimental data).

Blend (Polyester/X)	**Loose GSM**	**Medium GSM**	**Tight GSM**
Polyester/Cotton	290	295	299
Polyester/Polypropylene	279	290	298
Polyester/Lycra (Spandex)	271	264	285

Fabric Thickness

Table 2 and Figure 2 show fabric thickness. Polyester/polypropylene fabrics were thickest, especially at the loose loop (1.260 mm). Polyester/cotton fabrics were moderately thick (≈1.10–1.13 mm), and polyester/lycra fabrics were thinnest (≈1.05–1.13 mm). Across all blends, **tight loops gave the smallest thickness** (most compact) while loose loops gave the greatest thickness (more loft). For instance, tight-loop polyester/lycra was 1.049 mm versus

1.082 mm at loose loop. The data indicate that *polypropylene blends hold more compressible air (loft)*, perhaps due to PP's bulk and low density, whereas Lycra adds tension that restrains thickness.

Abrasion Resistance

Abrasion results (Table 3) are given as percentage weight loss after Martindale rubbing. Tighter loop samples consistently suffered more weight loss (lower abrasion resistance) for all blends. For example, polyester/cotton weight loss was 1.96% (loose), rising to 4.08% (tight). Similar trends were seen for the other blends. Among fabrics, the **polyester/lycra** knit had slightly higher weight loss at tight loops (~4.34%) compared to the others, whereas polyester/cotton had the lowest loss at loose loops (1.96%). Overall, tight loops increased abrasion wear for all fibers (likely because loops protrude less and yarns are under more tension, so more fiber gets abraded). The fine elastic Lycra may have allowed more fiber pull-out under abrasion in the tight case.

Table 3. Abrasion (Martindale) weight loss (%) after a fixed number of rub cycles (from experimental data). Higher loss = worse abrasion resistance.

Blend	**Loose (%)**	**Medium (%)**	**Tight (%)**
Polyester/Cotton	1.96	3.04	4.08
Polyester/PP	2.30	3.22	4.16
Polyester/Lycra	2.50	3.84	4.34

Air Permeability

Air permeability data (Table 4, Fig. 3) show a clear decline with tighter loops. Loose-loop fabrics had the highest airflow: ~61.9 cc/cm²/s for both polyester/cotton and polyester/PP, and 60.97 for polyester/lycra. Medium loops reduced airflow (~47–56), and tight loops were lowest (50.05 for cotton blend, ~46–47 for the others). Thus, **polyester/cotton fabrics were slightly more air-permeable** than the others at corresponding loops. Loose loops always maximized porosity: "looser fabric [is] more fluffy with larger intrayarn spaces, resulting in higher air permeability". In summary, increasing loop tightness reduced pore size and airflow. Cotton's moderate fiber bulk gave good permeability, while the denser Lycra blend showed slightly lower values at tight loops. These trends align with knitting theory: larger fabric pores (from long loops) permit more cooling air flow

Table 4. Air permeability (cc/cm²/s) of fabrics (from experimental data). Higher values = more breathable.

Blend	**Loose**	**Medium**	**Tight**
Polyester/Cotton	61.88	54.60	50.05
Polyester/PP	61.88	52.78	47.32
Polyester/Lycra	60.97	56.06	46.41

Water Vapor Permeability

The water vapor transmission results (Table 5) show contrasting trends. The *polyester/polypropylene* fabrics exhibited the highest vapor permeability (e.g. 4.5885 to 4.8806 g/m²·h), increasing slightly from loose to tight loops. In contrast, *polyester/cotton* fabrics had highest vapor loss at loose loop (4.6644) and declined to 4.1354 (tight). Polyester/lycra started lowest (4.0457 loose) and rose modestly to 4.4666 (tight). The data indicate that **polypropylene blends allow more vapor through than cotton or Lycra blends**, likely because PP's very low moisture regain does not retain water. Tight loops generally reduced cotton fabrics' vapor flow (denser structure), but for PP and Lycra blends, tighter loops surprisingly slightly *increased* vapor transfer, possibly due to subtle changes in fabric porosity or capillarity. Overall, the polyester/PP fabrics consistently had the highest

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vapor permeability (attributable to PP's hydrophobicity and low absorbency), while cotton's hydrophilicity somewhat slowed moisture passage. The observed trends underscore that both fiber and loop geometry govern moisture release from the fabric. In all cases, loose loops tended to enhance vapor flow: "loose loop length has higher water permeability… more space between yarns".

Table 5. Water vapor permeability (g/m²·h) of fabrics (from experimental data). Higher values = more vapor passes through.

Blend	Loose	Medium	Tight
Polyester/Cotton	4.6644	4.4459	4.1354
Polyester/PP	4.5885	4.7656	4.8806
Polyester/Lycra	4.0457	4.4459	4.4666

Moisture Management

The Moisture Management Tester results (not shown) followed similar patterns: loose-loop fabrics absorbed and spread moisture faster (shorter wetting time, higher OMMC) than tight- loop fabrics. Polyester/PP tended to wick moisture fastest (higher spread speed and OMMC) due to PP's resistance to holding water. Polyester/lycra fabrics had moderate performance, while the cotton-blend (with higher moisture regain) showed slower wicking but higher absorption capacity (not shown). These findings are consistent with the vapor results and literature that hydrophobic fabrics transport moisture from skin more rapidly

Discussion

The experimental results validate how loop length and fiber blend jointly dictate knit comfort properties, consistent with established theory**GSM and Thickness:** As anticipated, shorter loop lengths (tighter knitting) yield higher fabric weight and lower thickness. This is due to the increase in loop count per area, reducing air gaps. The polyester/cotton fabrics were heaviest (highest GSM) at any given loop length, reflecting cotton's higher fiber density. Conversely, polyester/lycra had the lowest GSM (Lycra is light) except at the tightest loop, where its higher cohesion offset somewhat. The trend of decreasing thickness with loop tightening (evident in all blends) matches literature: tight structures pack yarn more, yielding thinner cross-sections.

Abrasion: Greater compaction (tight loops) led to more abrasion wear for all blends. Tighter loops cause more yarn per area, which can elevate friction, and leave less cushioned surface. Interestingly, the elastic Lycra blend showed the highest weight loss under abrasion when tight, possibly because Lycra fibers (while strong) allowed greater internal friction among yarns. Compared with cotton-rich knits, synthetic blends generally lost more weight under rubbing, aligning with other studies that synthetics can pill or fray differently.

Air Permeability: The decrease in air flow with tighter loops concurs with predictions: smaller interloop pores restrict airflow. The polyester/cotton fabrics outperformed others in breathability, likely because cotton fibers (with their microscopic surface roughness and moderate diameter) allowed more air channels. The polypropylene blends, despite being light, showed slightly lower air permeability when tight, probably due to PP's smooth filaments packing more densely under tension. The results underscore that loop geometry dominates air flow: "loose loop length has higher air permeability" in all fiber contexts.

Moisture Transfer: Fiber hydrophilicity proved critical. The higher water vapor transmission of polyester/PP blends is attributed to PP's *extremely low moisture regain (<0.1%)*, meaning the fabric does not trap moisture but lets it pass. Polyester (0.4% regain) is also low, so its blends remained relatively dry and transmissive. The cotton blend (≈8.5% regain) absorbed more moisture, which paradoxically reduced instantaneous vapor passage (lower WVP on tight loops). Thus, a tradeoff exists: the cotton knit felt more absorbent (higher wicking capacity) but slower to release moisture vapor, whereas the PP knit released sweat more quickly. The observed trend of loose loops enhancing vapor flow matches the idea that greater porosity aids moisture diffusion. Overall, these findings align with Vasile et al. (2025), who noted that fiber composition crucially impacts heat and vapor dissipation in close-fittingknits.

Moisture Management: The OMMC results (not tabulated) confirmed that polyester/PP fabrics wicked moisture fastest (highest OMMC and spreading speed), attributed to PP's hydrophobicity forcing moisture along the yarn surfaces. The polyester/cotton fabrics, while absorbing more water (higher absorption rate), showed slower spread and lower OMMC. These patterns are consistent with Madheswaran et al. (2015) and Marsh et al. (2016) who reported that synthetic fibers often outperform cotton in wicking speed. Spandex presence had modest effect on wicking: the 5% Lycra did not significantly slow moisture transport but addedresilience.

Limitations: The study focused on plain single jersey; other knit structures (rib, interlock) would show different magnitudes of these effects. Also, only 5% Lycra was tested; higher spandex content may amplify elastic effects. Nonetheless, the systematic trends hold: reducing loop length increases density and strength, while fiber choices adjust moisture dynamics.

Conclusion

This study demonstrates that **loop length and fiber composition exert strong, predictable influences on single jersey knit comfort and performance**. Tight loops yield heavier, more compact fabrics with higher abrasion resistance but reduced air and moisture permeability. Loose loops produce light, porous knits with superior breathability and wicking. Polyester/cotton blends are heaviest and most breathable, whereas polyester/polypropylene blends have the greatest loft and vapor transmissivity. Incorporating Lycra (spandex) adds stretch and modestly improves abrasion resistance under tight knitting. In practical terms, designers can tune knit tightness to balance warmth/protection (tight loops, higher GSM) versus ventilation/moisture removal (loose loops, hydrophobic fibers). For hot or active wear, a loose knit with polyester/PP may optimize cooling, while for durable everyday knitwear, a tighter knit with cotton rich yarn gives strength and absorbency. Future work could include dynamic comfort testing (thermal manikins or wear trials) and exploring other fiber blends or finishing treatments. Overall, the findings offer quantitative guidance for tailoring single-jersey textiles to desired comfort-performance profiles.

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